**Development of Nitrogen Loading—Response Relationships for Estuarine Waters Using an Empirical Comparative Systems Approach**

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There is growing evidence that human activities have dramatically changed the amounts, distribution, and movement of major nutrient elements (nitrogen-N and phosphorus-P) in the landscape and have increased nutrient loading to receiving waters. Some of these changes affect use of the nation's aquatic resources and pose risks to human health and the environment. EPA's Office of Water is in the process of encouraging the States and Tribes to set up methods and procedures that will lead to the development of numeric nutrient standards protective of aquatic life. For waters that fail to meet water quality standards, States and Tribes are required to develop Total Maximum Daily Loads (TMDLs) to eliminate the causes of non-attainment. At present, we cannot extrapolate knowledge of nutrient load-response relationships from the few systems for which we have large amounts of data (e.g., Chesapeake Bay, Long Island Sound) to predict adverse effects on specific systems with more limited data. Sound methods and information on nutrient load-response relationships are required to develop and defend numeric nutrient criteria protective of aquatic life to manage nutrient risks for such systems.

A primary goal of NHEERL's Aquatic Stressors Nutrient Research Program is to provide the scientific basis and load-response relationships that are required to develop numeric nutrient criteria protective of aquatic life. As part of this effort, the Atlantic Ecology Division (AED), along with the Gulf, Western, and Mid-Continent Ecology Divisions, are implementing an integrated research plan whose goal is to develop stressor-response models for nutrients that are both scientifically robust and practical for marine and Great Lakes coastal waters. This research will advance and augment the current scientific basis for the developing water quality criteria as outlined in the technical guidance manual for estuaries.

As part of this regional approach, AED is in the second year of a multiyear research program to develop empirical nitrogen load-response models for coastal embayments in the Northeast USA. Models are under development using water quality indicators of hypoxia, food web attributes, and submerged aquatic vegetation (SAV). AED is evaluating 44 embayments along the Connecticut, RI, and southern Massachusetts coasts. Specifically, sediment profile imagery is used as an indicator of the intensity and duration of hypoxia. The first trophic level of the food web is assessed using airplane-mounted, remotely sensed chlorophyll-a as a biomass indicator for phytoplankton. SAV extent is determined using airplane-mounted digital photography. The approach is based on statistical associations, and predictions will apply to the class of systems used in the model development; however, by including systems with a wide range of loadings,

the model applicability increases. Preliminary data reveal a wide range of responses that appear to relate to nitrogen loads in the embayments. The field techniques and indicators used for the research program can be easily adapted and transferred to coastal environmental managers.